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On entropy and objective reality

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Abstract : This essay discusses Schördinger's answer to his question "What is Life?" in terms of negative entropy, as a thermodynamic description, rather than a fundamental explanation. Discussion is given to explaining a life system as an objective reality.

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Erwin Schrödinger wrote an interesting essay entitled : "What is Life?" [1]. He calls for a different type of physical force to explain the maintenance of a living organism in terms of 'negative entropy'.

The idea is this : According to the second law of thermodynamics, an initially ordered system, such as the union of a male sperm cell and a female egg, starts the process of continued cell division and duplication (mitosis), eventually resulting in a living entity that continues a lifespan until its expiration, at death. Accompanying the process of cell division and growth is the emergence of the ordered system proceeding toward increased disorder. This is described by the increase of entropy (disorder) until equilibrium is reached, at maximum entropy, which occurs at the death of the living being. In regard to human beings, the lifespan is normally much greater than the time of normal decay of a complex system to equilibrium.

The question is : How does this living organism maintain its lifespan? Schrödinger's answer is : 'negative entropy'. That is, there is negative entropy because of the metabolic process of transferring energy from the outside of the living organism, such as intake of food, air, and so on. The disorder of the system is then *decreased* during one's lifespan. This negative entropy slows down the process that nevertheless

eventually reaches the equilibrium state, (maximum entropy) at death, in accordance with the second law of thermodynamics.

The concept of entropy is fundamentally explained in physics in terms of a statistical feature of a many-body system, such as the complex molecular system of a human body. But does this statistical law, expressed as the second law of thermodynamics, really *explain* the life process? Does it answer Schrödinger's question : What is Life? in fundamental terms?

I don't believe so. In his book [1], Schrödinger (I believe correctly) denies the validity of the assertion that "all physical laws are based on statistics". As he says : "the order of the solar system, the motions of the planets, is maintained for almost indefinite time. The calculations do not imply any statistics; they are based solely on Newton's law of universal attraction. Nor does the motion of a good clock appear to have anything to do with statistics".

As I have discussed elsewhere [2], there are two stages to scientific inquiry. The first is the *descriptive stage*. The laws of statistics applied to a physical system are in this category. But the descriptive stage of science is not the goal intended by the scientist. It must lead to an *explanatory stage*. This is the stage of discovering the fundamental principles that *underlie* the empirical aspects of science.

Consider, for example, the subject of molecular biology. Fundamental principles (*i.e.* universals) are at first speculated, based on hints from the empirical facts, and with the further use of one's intuition, a theory is formulated, leading to the role of the DNA molecule, and so on. This theory then leads to particulars that relate to the empirical data. If these agree with the actual experimental facts, then one may say (at least contingently!) that the theory is an explanation that is scientifically true.

The adjective "scientifically" implies that this is only a contingent truth — it is subject to refutation. This is the way that we discover truth in any scientific endeavor — be it physics, chemistry, or molecular biology. We proceed to the truth by successive approximations in the different periods of science, continually refuting ideas based on new empirical evidence that does not support the older ideas and continually accepting new ideas. I believe that the history of science is evolutionary rather than revolutionary. There are threads of truth that do persist from one period of normal science to the next (to use T S Kuhn's terminology [3]). Thus the history of science reveals a positive flow in our continued understanding of nature.

On Schrödinger's question: What is Life?, I don't believe that his thermodynamic argument about 'negative entropy' is an *explanation* for the life process. Of course, the thermodynamic description is true, but it is only at the descriptive level. That is to say, this is a *subjective* statement about an *objective* reality. What the scientist wants to get to, eventually, is a fundamental explanation of the objective reality, independent of our subjective knowledge.

I believe that Schrödinger was stimulated to look into this biological question by his pioneering research on the physics of quantum mechanics. This is a *statistical*

theory of the microdomain of matter. Thus, quantum mechanics is a subjective description rather than an objective description. It is then understandable that the quantum theory is not intrinsically explanatory.

The eminent theoretical physicist, Richard Feynman, expressed the fact that quantum mechanics is not an explanatory theory in physics when he said the following about this subject [4] : "The next question is, will you understand what I am going to tell you? (*i.e.* does quantum mechanics explain nature?) No, you are not going to be able to understand it. It is my task to convince you *not* to turn away because you don't understand it. You see, my physics students don't understand it either. That is because I don't understand it. Nobody does".

It is my assertion that nobody understands quantum mechanics, *i.e.* as an explanation, because it is a purely statistical theory. It is not supposed to be explanatory in the first place – it does not yield any fundamental understanding in physics. It is purely descriptive.

As an example, consider the toss of a coin. It flip-flops into the air, turns around, falls toward the ground and then lands. What is the probability that it will land head? Because the head and tail are two equally weighted sides of the coin, the probability that it will land head is 1/2. Empirically, this means that if the coin is tossed 1000 times, it will land head close to 500 times.

But there is an objective path of the tossed coin. If I knew the initial force on it to start its motion upward, the force of gravity acting on it to make it return to earth, the forces of the air molecules that interact with the coin, *etc.*, then I could find a unique solution of the equation of motion of the coin that predicts with certainty whether it will land head or tail. But I do not know all of these details, so I subjectively use a probability theory to determine the *chance* that it will land head. But the latter is not explanatory regarding the objective path of the coin! It is only descriptive. It does not mean that there is not an underlying objective path of the coin!

Similarly, the entropy of a complex molecular system, such as a living human body, is a subjective feature about its state of disorder, *according to our observations.* Schrödinger's description of the living process in terms of negative entropy is then true, but not more than a subjective description. It is not an explanation, underlying objective laws of nature applied to the life process.

Another example would be the universe itself — the subject of cosmology. Is it meaningful to talk about the entropy of the universe? I don't believe so since it is out of context! The universe is a closed system, by definition. Its physical nature is not tied to our lack of knowledge of its total intrinsic order. This is the order that underlies the dynamics of the entire universe. Our *knowledge* (or lack of knowledge) of the details of the universe — the planetary systems, the galaxies and their interactions, the expansion of the universe ... is in a different context than the laws of the universe itself. To say that a law of the universe is a law of thermodynamics is to confuse

epistemology (a theory of knowledge) with ontology (a theory of what exists, independent of our knowledge of it).

Einstein was a realist. He did not believe that the laws of physics are the laws of statistics. Most contemporary physicists are positivists — they believe that all that is necessary for the scientist to do is to describe. The latter is the reason for Feynman's assertion about quantum mechanics that "my task is to convince you *not* to turn away because you don't understand it. Nobody does". He then believes that a scientist should not try to explain a physical theory, such as quantum mechanics. It is sufficient to describe the facts of nature. This is the philosophical view of *positivism.* Einstein, on the other hand, did believe that the final stage of a scientific study is explanation of natural phenomena, in terms of first principles. It is the philosophy of *realism.*

It is my firm belief that the 21st century will see a paradigm change in the philosophy of physics from positivism to realism.

I should like to re-emphasize that I do not disagree with Schrödinger on the *description* of the life process in terms of negative entropy. My only stress is that this is not an *explanation* of life. That is to say, it does not derive the physical features of the life process from first principles. 'First principles' are not a mere correlation of facts. They are the premises that lead, by logical deduction, to the empirical facts of nature. Indeed, it is the 'first principles' that are our 'understanding' of the facts of nature.

Schrödinger agreed (as I have quoted in this essay), that the first principles of the laws of nature are not the rules of statistics. Though statistics plays an important role in the *description* of many body systems, I do not believe that Schrödinger (nor Einstein) thought that the fundamental laws of nature are laws of chance.

Science is presently at a very early stage in the attempt to *explain* the life process. The best hope I see for this explanation is in the field of molecular biology. In this field of science we presently have accurate *descriptions* of the elements of a living system — the DNA molecule, its atomic constituents and its spiral configuration. But there is little understanding yet of the fundamental mechanisms, based on first principles, that underlie the life process.

As a non-expert in the field of biology, I would like to speculate, as a physicist, on the problem of life. I am quite convinced (with Schrödinger and Einstein) of the truth of the continuous field concept in the laws of nature, in contrast with the atomistic model. Applied to molecular biology, the DNA molecule, as an element of a biological system, has a very large number of atomic constituents. Would it be possible to study this problem holistically, as a closed system, from the view of many continuous fields (one for each atomic constituent) but not in terms of singular atoms? The atomic model of DNA would entail the many-body problem — seeking a solution for an enormous number of coupled equations and their boundary conditions – an intractable mathematical problem. But in the holistic, field theory of the DNA molecule,

there are many coupled fields (each mapped in a single space, without the 'entanglement' that Schrödinger refers to). This mathematical representation of a closed system is necessarily in terms of nonlinear differential equations. This is in contrast with the linearity of the quantum mechanical description of a many body system. The mechanism that we seek to explain the life process, may be in the mathematical solutions of such a nonlinear, holistic field theory of DNA. This indeed could be a start for an explanation of the life process. It is my speculation about the way of representing the fundamental mechanism of the life process, holistically rather than atomistically.

References

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